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I hereby declare and state:

that I am thoroughly conversant in both the Korean language and the English language;

that I am presently engaged as a translator in both the Korean and English languages; and

that the attached document represents a true and complete English translation of Korean Patent Application No. 10-2003-0023989 filed on April 16, 2003.

I further declare that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 3rd day of December, 2008

Yoon

Translator: You kyung, YOON

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[Title of Invention] ENERGY RECOVERING APPARATUS AND METHOD OF PLASMA DISPLAY PANEL

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[Document To Be Amended] Specification and the like

[What To Be Amended]

[Item To Be Amended] As attached

[Method To Amend] As attached

[Content of Amendment] As attached

[Intent] This is submitted pursuant to enforcement regulations of patent law article 13 and enforcement regulations of utility model law article 8

Attorney KIM YOUNG HO (seal)

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[AMENDMENT]

[ITEM TO BE AMENDED] Summary

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[SUMMARY]

The present invention relates to an energy recovering apparatus and recovering method of a plasma display panel that may minimize conductive losses of currents caused by switching elements and simplify the circuit construction.

The energy recovering apparatus of the plasma display panel includes a panel; a first power source generating a sustain voltage having a first polarity; a second power source generating a sustain voltage having a second polarity; a first switch forming a current path between the first power source and the panel; a second switch forming a current path between the second power source and the panel; an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and a switch circuit forming a current path between the inductor and the panel.

[ITEM TO BE AMENDED] Identification number 37

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Referring to Fig. 2, energy recovering apparatus 30 and 32 of the PDP having been suggested by U.S. Pat. No. 5,081,400 of Weber are symmetrically arranged with respect to a panel capacitor Cp. The panel capacitor Cp is an equivalent expression of capacitance formed between

the first electrode Y and the second electrode Y. The first energy recovering apparatus 30 applies a sustain pulse to the first electrode Y. The second energy recovering apparatus 32 operates alternately with respect to the first energy recovering apparatus 30 to thereby apply a sustain pulse to the second electrode Z.

[ITEM TO BE AMENDED] Identification number 38

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

A construction of the conventional energy recovering apparatus 30 and 32 of the PDP will be described with respect to the first energy recovering apparatus 30. The first energy recovering apparatus 30 includes an inductor L connected between the panel capacitor Cp and a source capacitor Cs, first and third switches S1 and S3 connected in parallel with each other between the source capacitor Cs and the inductor L, and second and fourth switches S2 and S4 connected in parallel with each other between the panel capacitor Cp and the inductor L.

[ITEM TO BE AMENDED] Identification number 49

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Referring to Fig. 4, an energy recovering apparatus for a PDP suggested by NEC (U. S. Pat. No. 5,670,974) includes a panel capacitor 40 equivalently representing capacitance formed between a scanning electrode and a sustain electrode of the PDP 1, and a charging/discharging circuit 2 and a voltage clamp circuit 3 connected in parallel with the panel capacitor Cp. In particular, the charging/discharging circuit

2 includes a coil 8 connected in parallel with the panel capacitor 40 of the panel 1 to re-charge a reverse polarity of a resonant current generated when the panel capacitor 40 is discharged, and two switches 12 and 13. The switches 12 and 13 form a bi-directional switch with respect to the coil 8. One side of the panel capacitor 40 is connected, in series, to the two switches 12 and 13 formed from N-channel FET's controlled by different switch drive inputs IN 5 and IN 6 supplied to their respective gate terminals and reverse current blocking diodes 10 and 11 connected in series with the respective switches 12 and 13. Other side of the panel capacitor 40 is connected to one end of the parallel circuit having the coil 8 and a resistor 9. To the other end of the parallel circuit, the other terminal of the diodes 10 and 11 are connected commonly. The panel capacitor 40 and the charging/discharging circuit 2 of the panel form a parallel resonant circuit. In the meanwhile, the resistor 9 connected in parallel with the coil 8 of the charging/discharging circuit 2 is a damping resistor provided for the purpose of preventing an oscillation of a waveform.

[ITEM TO BE AMENDED] Identification number 51

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

The energy recovering apparatus of the PDP forms a parallel resonant circuit using the panel capacitor 40 of the panel 1 and the coil 8 of the charging/discharging circuit 2, and repeats charging/discharging of the panel capacitor 40 by driving each of the switches 4, 5, 6, and 7 to reduce reactive power.

[ITEM TO BE AMENDED] Identification number 60

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

The energy recovering apparatus of the PDP which has been suggested by NEC (U. S. Pat. No. 5670974) requires an energy recovering circuit and a sustain circuit for each of the scanning electrode and the sustain electrode of the PDP 1 to thereby cause a complex circuit configuration. Accordingly, it has a problem in that a manufacturing cost rises. Furthermore, the energy recovering apparatus of the PDP which has been suggested by NEC (U. S. Pat. No. 5670974) consumes much power due to conductive losses of the switches although they are smaller than those of the energy recovering apparatus suggested by Weber (U. S. Pat. No. 5081400)

[ITEM TO BE AMENDED] Identification number 61

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Accordingly, an object of the present invention is to provide an energy recovering apparatus and method of a PDP that may minimize current conductive losses due to switching elements and simplify circuit constructions.

[ITEM TO BE AMENDED] Identification number 62

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

To achieve the above object, an energy recovering apparatus of a PDP according to an embodiment of the present invention includes a

PDP panel; a first power source generating a sustain voltage having a first polarity; a second power source generating a sustain voltage having a second polarity; a first switch forming a current path between the first power source and the panel; a second switch forming a current path between the second power source and the panel; an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and a switch circuit forming a current path between the inductor and the panel.

In the energy recovering apparatus of the plasma display panel, the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

In the energy recovering apparatus of the plasma display pane, the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

In the energy recovering apparatus of the plasma display panel, the switch circuit includes third and fourth switches arranged in parallel with each other between the inductor and the panel, a first diode connected between the third switch and the panel to interrupt a reverse current from the panel capacitor, and a second diode connected between the fourth switch and the panel to interrupt a reverse current from the fourth switch.

In the energy recovering apparatus of the plasma display panel, the third switch forms a current path between the inductor and the panel

via the first diode during a period while a voltage across the panel rises from the sustain voltage having the second polarity to the sustain voltage having the first polarity.

In the energy recovering apparatus of the plasma display panel, the fourth switch forms a current path between the inductor and the panel via the second diode during a period while a voltage across the panel falls from the sustain voltage having the first polarity to the sustain voltage having the second polarity.

An energy recovering method of a plasma display panel according to an embodiment of the present invention includes a first step of forming a current path between the first power source and the panel using a first switch to charge a sustain voltage having a first polarity supplied from the first power source to the panel; a second step of forming a current path between the second power source and the panel using a second switch to charge a sustain voltage having a second polarity supplied from the second power source to the panel; and a third step of recovering energy stored in the panel by a resonance with the panel to supply the recovered energy to the panel.

[ITEM TO BE AMENDED] Identification number 63

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 64

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 65

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 66

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[ITEM TO BE AMENDED] Identification number 67

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[METHOD TO AMEND] Deletion

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[METHOD TO AMEND] Deletion

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[METHOD TO AMEND] Deletion

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[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 76

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 77

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Identification number 78

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Other objects than the above objects and features of the present invention will be apparent through descriptions on embodiments with reference to accompanying drawings.

[ITEM TO BE AMENDED] Identification number 80

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Referring to Fig. 7, an energy recovering apparatus of a PDP (Plasma Display Panel: hereinafter, referred to as "PDP") according to an embodiment of the present invention includes a panel capacitor Cp provided equivalently with first and second electrodes of the PDP, a first sustain voltage source +VS that generates a voltage +VS having a first polarity, a second sustain voltage source that generates a voltage -VS having a second polarity which is opposite to the first polarity, a first switch Q1 connected between the first sustain voltage source +VS and one end, i.e. a first electrode of the panel capacitor Cp, a second switch Q2 connected between the second sustain voltage source -VS and the first electrode, an inductor L connected between a first node point N1 between the first and second switches Q1 and Q2 and a second node point N2 between the first and second voltage sources +VS and -VS, and third and fourth switches Q3 and Q4 connected in parallel with each other between the inductor L and the first node point N1.

[ITEM TO BE AMENDED] Identification number 91

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Periodic repetition of such periods T1 to T3 enables an AC sustain pulse VCP to be supplied to the panel capacitor Cp. In reality, an AC driving pulse (VCP) supplied to a first electrode Y and a second electrode Z of the PDP is generated while the above-mentioned periods T1 to T3 are repeated periodically.

[ITEM TO BE AMENDED] Identification number 93

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

As described above, the energy recovering apparatus and method of the PDP according to the embodiment of the present invention charges energy to the inductor while a sustain voltage is supplied to the panel capacitor, and recovers the energy charged to the panel capacitor using a reverse voltage upon energy recovery, with the recovered energy supplied back to the panel capacitor. This enables the rising and falling slope of the sustain waveform to be steep upon energy recovery.

[ITEM TO BE AMENDED] Identification number 94

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

Further, the present invention has an advantage of being capable of configuring an energy recovering apparatus at only one of the first and second electrodes of the PDP. Since only one switching element exists over the sustain current path, the present invention may minimize the conductive losses by the switching element. In the meanwhile, the present invention may reduce consumption power because of four switching elements and two diodes.

[ITEM TO BE AMENDED] Claim 1

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 1]

An energy recovering apparatus of a plasma display panel comprising:

a plasma display panel;

a first power source generating a sustain voltage having a first polarity;

a second power source generating a sustain voltage having a second polarity;

a first switch forming a current path between the first power source and the panel;

a second switch forming a current path between the second power source and the panel;

an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and

a switch circuit forming a current path between the inductor and the panel.

[ITEM TO BE AMENDED] Claim 2

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Claim 3

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Claim 4

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 4]

The energy recovering apparatus of the plasma display panel of claim 1, wherein the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

[ITEM TO BE AMENDED] Claim 5

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 5]

The energy recovering apparatus of the plasma display panel of claim 1, wherein the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

[ITEM TO BE AMENDED] Claim 6

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 6]

The energy recovering apparatus of the plasma display panel of claim 1, wherein the switch circuit includes third and fourth switches arranged in parallel with each other between the inductor and the panel, a first diode connected between the third switch and the panel to interrupt a reverse current from the panel capacitor, and a second diode connected between the fourth switch and the panel to interrupt a reverse current from the fourth switch.

[ITEM TO BE AMENDED] Claim 9

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 9]

An energy recovering method of a plasma display panel comprising:

a first step of forming a current path between the first power source and the panel using a first switch to charge a sustain voltage having a first polarity supplied from the first power source to the panel;

a second step of forming a current path between the second power source and the panel using a second switch to charge a sustain voltage having a second polarity supplied from the second power source to the panel; and

a third step of recovering energy stored in the panel by a resonance with the panel to supply the recovered energy to the panel.

[ITEM TO BE AMENDED] Claim 10

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Claim 11

[METHOD TO AMEND] Deletion

[ITEM TO BE AMENDED] Claim 12

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 12]

The energy recovering method of the plasma display panel of claim 9, wherein the

the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

[ITEM TO BE AMENDED] Claim 13

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 13]

The energy recovering method of the plasma display panel of claim 9, wherein the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

[ITEM TO BE AMENDED] Claim 14

[METHOD TO AMEND] Correction

[CONTENT OF AMENDMENT]

[Claim 14]

The energy recovering method of the plasma display panel of claim 9, wherein the third step includes a step of forming a current path between the inductor and the panel using a third switch, a step of interrupting a reverse current from the panel using a first diode connected between the third switch and the panel, a step of forming a current path between the inductor and the panel using a fourth switch, and a step of interrupting a reverse current from the fourth switch using a first diode connected between the fourth switch and the panel.

[BIBLIOGRAPHY]

[Document name] Patent Application

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[Title of Invention] ENERGY RECOVERING APPARATUS AND METHOD OF PLASMA DISPLAY PANEL

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[Substantial Examination] Request

[Intention] We file a patent application pursuant to patent law article 42 and request substantial examination pursuant to patent law article 60

Attorney KIM, YOUNG HO

[Fee]

[Basic Fee]	20 pages	29,000 Won
[Additional Fee]	15 pages	15,000 Won
[Priority Claim Fee]	0 case	0 Won
[Substantial Examination Fee]	16 claims	621,000 Won
[Sum]		665,000 Won

[Attached document] 1. Abstract/Specification (drawings)

[ABSTRACT]

[SUMMARY]

The present invention relates to an energy recovering apparatus and recovering method of a plasma display panel that may minimize conductive losses of currents caused by switching elements and simplify the circuit construction.

The energy recovering apparatus of a plasma display panel according to the present invention includes a plasma display panel; a power supply supplying a sustain voltage to the panel via a first switching element; an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and a second switching element forming a current path between the inductor and the panel.

[REPRESENTATIVE DRAWING]

Fig. 7

[SPECIFICATION]

[TITLE OF INVENTION]

ENERGY RECOVERING APPARATUS AND METHOD OF PLASMA DISPLAY PANEL

[BRIEF DESCRIPTION OF DRAWINGS]

Fig. 1 is a perspective view illustrating a conventional three-electrode AC surface discharge-type plasma display panel.

Fig. 2 is a circuit diagram illustrating an energy recovering apparatus of a conventional plasma display panel.

Fig. 3 is a timing diagram and a waveform diagram illustrating on/off timing of the switches shown in Fig. 2 and an output waveform of a panel capacitor.

Fig. 4 is a circuit diagram illustrating an energy recovering apparatus of another conventional plasma display panel.

Fig. 5 is a timing diagram and a waveform diagram illustrating on/off timing of the switches shown in Fig. 4 and an output waveform of a panel capacitor.

Fig. 6A is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 5 during a period A'.

Fig. 6B is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 5 during a period B.

Fig. 6C is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 5 during a period C.

Fig. 6D is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 5 during a period D.

Fig. 6E is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 5 during a period A.

Fig. 7 is a circuit diagram illustrating an energy recovering apparatus of a plasma display panel according to an embodiment of the present invention.

Fig. 8 is a timing diagram and a waveform diagram illustrating on/off timing of switches shown in Fig. 7 and an output waveform of a panel capacitor.

Fig. 9 is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 8 during a period T0.

Fig. 10 is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 8 during a period T1.

Fig. 11 is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 8 during a period T2.

Fig. 12 is a circuit diagram illustrating an on/off state and a current path of the switches shown in Fig. 8 during a period T3.

<DESCRIPTIONS OF KEY ELEMENTS IN DRAWINGS>

1: plasma display panel	2: charging circuit unit
3: clamp unit	4, 5, 6, 7: switch
8: inductor	9: resistor
12, 13: FET	10: upper substrate
12Y: first electrode	12Z: second electrode
14, 22: dielectric layer	16: protective film
18: lower substrate	20X: address electrode

24: barrier rib 26: fluorescent material

30, 32: energy recovering apparatus 40: panel capacitor

[DETAILED DESCRIPTION OF INVENTION]

[OBJECT OF INVENTION]

[TECHNICAL FIELD AND BACKGROUND OF INVENTION]

The present invention relates to an energy recovering apparatus and recovering method of a plasma display panel, and more particularly to an energy recovering apparatus and recovering method of a plasma display panel that may minimize conductive losses of currents caused by switching elements and simplify the circuit construction.

Recently, there have been developed various flat panel devices that are capable of reducing weight and bulk. Such flat panel display devices include a liquid crystal display (LCD), a field emission display (FED), a plasma display panel (hereinafter, referred to as "PDP") and an electro-luminescence display (ELD).

The PDP uses a gas discharge, and allows manufacture of a large-dimensional panel. The PDP typically includes three electrodes which is preferably driven with an AC voltage.

Among these, PDPs, which are a display component using a gas discharge, have an advantage of being capable of easily manufacturing a large-size panel. A representative PDP is a three-electrode AC surface discharge-type PDP which has three electrodes and is driven by an AC voltage as shown in Fig. 1.

Referring to Fig. 1, a discharge cell of the three-electrode AC

surface discharge-type PDP includes a first electrode 12Y and a second electrode 12Z provided on an upper substrate 10, and an address electrode 20X provided on a lower substrate 18.

On the upper substrate 10 provided preferably with the first electrode 12Y and the second electrode 12Z in parallel, an upper dielectric layer 14 and a protective film 16 are disposed. Wall charges generated upon plasma discharge are preferably accumulated near the upper dielectric layer 14. The protective film 16 prevents damage to the upper dielectric layer 14 due to sputtering generated upon plasma discharge as well as raises emission efficiency of secondary electrons. The protective film 16 is generally made of MgO.

A lower dielectric layer 22 and barrier ribs 24 are formed on the lower substrate 18 provided with the address electrode 20X. The surfaces of the lower dielectric layer 22 and the barrier ribs 24 are coated with a fluorescent material 26. The address electrode 20X is formed in a direction crossing the first electrode 12Y and the second electrode 12Z. The barrier rib 24 is formed in parallel to the address electrode 20X to prevent ultraviolet rays and visible light created by discharge from leaking to neighboring discharge cells.

The fluorescent material 26 is excited by ultraviolet rays emitted upon plasma discharge to generate one of red, green, and blue visible light rays. An inert gas is inserted into a discharge space formed by upper/lower plates and barrier ribs to create a gas discharge.

The three-electrode AC surface discharge-type PDP is driven based on a number of sub-fields. In each sub-field interval, a light emission

having a frequency proportional to a weighting value of video data is conducted to provide a gray scale display. Each sub-field is divided into an initialization period, an address period, a sustain period, and an erasure period.

The initialization period is generally a period for uniformly forming wall charges on the discharge cell. The address period is a period for generating a selective address discharge in accordance with a logical value of the video data. The sustain period is a period for allowing a discharge cell in which the address discharge has been generated to sustain a discharge. The erasure period is a period for erasing a sustain discharge generated in the sustain period.

The address discharge and the sustain discharge of the AC surface discharge-type PDP driven in the above manner requires a high voltage of more than hundreds of volts. Accordingly, an energy recovering apparatus is used for the purpose of minimizing driving power required for the address discharge and the sustain discharge. The energy recovering apparatus recovers a voltage between the first electrode 12Y and the second electrode 12Z, to thereby use the recovered voltage as a driving voltage upon the next discharge.

Referring to Fig. 2, energy recovering apparatus 30 and 32 of the plasma display panel having been suggested by U.S. Pat. No. 5,081,400 of Weber are symmetrically arranged with respect to a panel capacitor Cp. The panel capacitor Cp is an equivalent expression of capacitance formed between the first electrode Y and the second electrode Y. The first energy recovering apparatus 30 applies a sustain pulse to the

first electrode Y. The second energy recovering apparatus 32 operates alternately with respect to the first energy recovering apparatus 30 to thereby apply a sustain pulse to the second electrode Z.

A construction of the conventional energy recovering apparatus 30 and 32 of the plasma display panel will be described with respect to the first energy recovering apparatus 30. The first energy recovering apparatus 30 includes an inductor L connected between the panel capacitor Cp and a source capacitor Cs, first and third switches S1 and S3 connected in parallel with each other between the source capacitor Cs and the inductor L, and second and fourth switches S2 and S4 connected in parallel with each other between the panel capacitor Cp and the inductor L.

The second switch S2 is connected to a sustain voltage source VS and the fourth switch S4 is connected to ground GND. The source capacitor Cs recovers and charges a voltage charged to the panel capacitor Cp upon a sustain discharge, and supplies the charged voltage back to the panel capacitor Cp. A Voltage whose magnitude corresponds to half of that of the sustain voltage source Vs, i.e. Vs/2, is charged to the source capacitor Cs. The inductor L forms a resonance circuit together with the panel capacitor Cp. The first to fourth switches S1 to S4 control the flow of currents.

Meanwhile, a fifth diode D5 and a sixth diode D6, which are provided between the first switch S1 and the inductor L and between the second switch and the inductor L, respectively, prevent currents from flowing in the reverse direction.

Fig. 3 is a timing diagram and a waveform diagram illustrating

on/off timing of switches in the first energy recovering apparatus and an output waveform of the panel capacitor.

For the detailed descriptions on operations, it is assumed that before a period T1, the panel capacitor Cp is charged with a voltage of 0Volt and the source capacitor Cs is charged with a voltage of Vs/2.

During a period T1, the first switch S1 turns on to form a current path connecting from the source capacitor Cs through the first switch S1 and the inductor L to the panel capacitor Cp. After the current path is formed, the voltage of Vs/2 that has been charged to the source capacitor Cs is supplied to the panel capacitor Cp. At this time, since the inductor L and the panel capacitor Cp forms a series resonant circuit, the panel capacitor Cp is charged with a voltage of Vs which is two times the voltage of the source capacitor Cs.

During a period T2, the second switch S2 turns on. When the second switch S2 turns on, a voltage is supplied from the sustain voltage source Vs to the first electrode Y. The voltage supplied from the sustain voltage source Vs to the first electrode Y prevents the voltage of the panel capacitor Cp from falling lower than the voltage from the sustain voltage source Vs, thus enabling a sustain discharge to normally occur. Meanwhile, since the voltage of the panel capacitor Cp has risen up to Vs during the period T1, driving power is minimized which is externally supplied for creating a sustain discharge.

During a period T3, the first switch S1 turns off. At this time, the first electrode Y maintains the voltage of the sustain voltage source Vs during the period T3. During a period T4, the second switch S2 turns

off and simultaneously the third switch S3 turns on. When the third switch S3 turns on, a current path is formed which connects from the panel capacitor Cp through the inductor L and the third switch S3 to the source capacitor Cs to recover the voltage charged to the panel capacitor Cp back to the source capacitor Cs. At this time, the source capacitor Cs is charged with a voltage of Vs/2.

During a period T5, the third switch S3 turns off and simultaneously the fourth switch S4 turns on. When the fourth switch S4 turns on, a current path is formed between the panel capacitor Cp and the ground GND to lower the voltage of the panel capacitor Cp to 0Volt. During a period T6, the state in the period T5 is maintained for a constant time. Actually, an AC driving pulse supplied to the first electrode Y and the second electrode Z is obtained while the periods T1 to T6 are periodically repeated.

Meantime, the second energy recovering apparatus 32 is alternately operated with the first energy recovering apparatus 30 to supply a driving voltage to the panel capacitor Cp. Accordingly, sustain pulse voltages having the opposite polarity to each other are supplied to the panel capacitor Cp. By doing so, a sustain discharge occurs in the discharge cells.

However, these conventional energy recovering apparatuses 30 and 32 required many circuit parts (switching elements and the like) since the first energy recovering apparatus 30 provided at the first electrode Y side and the second energy recovering apparatus 32 provided at the second electrode Z side are operated independently from each other,

thus causing increase in manufacturing costs. Moreover, the conventional energy recovering apparatus consumed much power due to conductive losses of a number of switches (diodes, switching elements, and inductors) over the current paths.

Referring to Fig. 4, an energy recovering apparatus for a plasma display panel suggested by NEC (U. S. Pat. No. 5,670,974) includes a panel capacitor 40 equivalently representing capacitance formed between a scanning electrode and a sustain electrode of the plasma display panel 1, and a charging/discharging circuit 2 and a voltage clamp circuit 3 connected in parallel with the panel capacitor Cp. In particular, the charging/discharging circuit 2 includes a coil 8 connected in parallel with the panel capacitor 40 of the panel 1 to re-charge a reverse polarity of a resonant current generated when the panel capacitor 40 is discharged, and two switches 12 and 13. The switches 12 and 13 form a bi-directional switch with respect to the coil 8. One side of the panel capacitor 40 is connected, in series, to the two switches 12 and 13 formed from N-channel FET's controlled by different switch drive inputs IN 5 and IN 6 supplied to their respective gate terminals and reverse current blocking diodes 10 and 11 connected in series with the respective switches 12 and 13. Other side of the panel capacitor 40 is connected to one end of the parallel circuit having the coil 8 and a resistor 9. To the other end of the parallel circuit, the other terminal of the diodes 10 and 11 are connected commonly. The panel capacitor 40 and the charging/discharging circuit 2 of the panel form a parallel resonant circuit. In the meanwhile, the resistor 9 connected in parallel

with the coil 8 of the charging/discharging circuit 2 is a damping resistor provided for the purpose of preventing an oscillation of a waveform.

The voltage clamp circuit 3 includes first to fourth switches 4, 5, 6 and 7, of which the first and third switches 4 and 6 are respectively connected between one of two terminals of the panel capacitor 40 and power source terminals GND and -VS while the second and fourth switches 5 and 7 are respectively connected between the other of the terminals of the panel capacitor 40 and the power source terminals GND and -VS. The first and second switches 4 and 5 are P-channel FET's, and the third and fourth switches 6 and 7 are N-channel FET's. The switches 4, 6 and the switches 5, 7 form the CMOS type circuit structures, respectively.

The energy recovering apparatus of the plasma display panel forms a parallel resonant circuit using the panel capacitor 40 of the panel 1 and the coil 8 of the charging/discharging circuit 2, and repeats charging/discharging of the panel capacitor 40 by driving each of the switches 4, 5, 6, and 7 to reduce reactive power.

Fig. 5 is a waveform diagram representing driving voltage and drive current waveforms in the panel shown in Fig. 4. Referring to Fig. 5, waveforms IN 1 to IN 6 are input waveforms for driving the switches 4, 5, 6, and 7, and the FET switches 12 and 13 shown in Fig. 4. The waveform VCP is a voltage waveform applied across both ends of the panel capacitor 40, and the waveform IL is a current waveform flowing across the coil 8.

For the detailed descriptions on operations, it is assumed that no charges have been charged to the panel capacitor 40 of the panel

1 before a period A', that is, at t=0.

During the period A', when the second switch 4 and the fourth switch 7 turn on, a current path is formed which connects from the ground GND through the first switch 4, the panel capacitor 40, and the fourth switch 7 to a reverse voltage source -VS as shown in Fig. 6A. When the current path is formed, the panel capacitor is charged with charges.

During a period B, when the switch 12 turns on, a current path is formed which connects from one end of the panel capacitor 40 through the coil 8, the diode 10, and the switch 12 to the other end of the panel capacitor 40 as shown in Fig. 6B. When the current path is formed, a discharge current is supplied from the panel capacitor 40 to the coil 8. At this time, since a counter electromotive force is generated at the coil 8 so that a resonant current IL flows, the voltage VCP applied to the panel capacitor 40 becomes the maximum reverse voltage -VS when the current flowing across the panel capacitor 40 reaches zero.

During a period C, when the panel capacitor 40 is applied with the maximum reverse voltage -VS, the second switch 5 and the third switch 6 turn on to form a current path connecting from the ground GND through the second switch 5, the panel capacitor 40, and the third switch 6 to the reverse voltage source -VS as shown in Fig. 6C. When the current path is formed, one end of the third switch 6 of the panel capacitor 40 is clamped. At this time, the panel capacitor 40 comes to have the revere polarity during the period A'.

During a period D, the second and third switches 5 and 6 turn off and then the switch 13 turns on. Therefore, a current path is formed

which connects from the other end of the panel capacitor 40, the switch 13, and the coil 8 to the one end of the panel capacitor 40 during the period D as shown in Fig. 6D. When the current path is formed, charges stored in the panel capacitor 40 are discharged to the coil 8. That is, a reverse current IL comes to flow in the reverse direction of the current flowing during the period B. In the meanwhile, when the voltage VCP of the panel capacitor 40 rises up to 0, the maximum current comes to flow across the coil 8. Accordingly, a reverse voltage is recharged to the panel capacitor 40.

When recharging of the reverse voltage to the panel capacitor 40 is ended by a counter electromotive force of the coil 8 during a period A, the switch 13 turns off and the first and fourth switches 4 and 7 turn on as shown in Fig. 6E. Accordingly, charges stored in the panel capacitor 40 are maintained until the next cycle. Then, the periods A' to D are repeated.

As such, the energy recovering apparatus of the PDP may reduce charging/discharging power of the panel capacitor 40 by a resonant operation that controls timing of each switch, the panel capacitor 40, and the coil 8, and recover most of the reactive power during the former cycle to the parts until the next cycle.

The energy recovering apparatus of the PDP which has been suggested by NEC (U. S. Pat. No. 5670974) requires an energy recovering circuit and a sustain circuit for each of the scanning electrode and the sustain electrode of the plasma display panel 1 to thereby cause a complex circuit configuration. Accordingly, it has a problem in that a manufacturing

cost rises. Furthermore, the energy recovering apparatus of the PDP which has been suggested by NEC (U. S. Pat. No. 5670974) consumes much power due to conductive losses of the switches although they are smaller than those of the energy recovering apparatus suggested by Weber (U. S. Pat. No. 5081400).

[TECHNICAL PROBLEMS TO BE SOLVED BY INVENTION]

Accordingly, an object of the present invention is to provide an energy recovering apparatus and method of a plasma display panel that may minimize current conductive losses due to switching elements and simplify circuit constructions.

[CONSTRUCTION OF THE INVENTION]

To achieve the above object, an energy recovering apparatus of a plasma display panel according to an embodiment of the present invention includes a plasma display panel; a power supply supplying a sustain voltage to the panel via a first switching element; an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and a second switching element forming a current path between the inductor and the panel.

In the energy recovering apparatus of the plasma display panel, the power supply includes a first power source charging a sustain voltage having a first polarity to the panel and a second power source charging a sustain voltage having a second polarity opposite to the first polarity to the panel.

In the energy recovering apparatus of the plasma display panel, the first switching element includes a first switch forming a current

path between the first power source and the panel and a second switch forming a current path between the second power source and the panel.

In the energy recovering apparatus of the plasma display panel, the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

In the energy recovering apparatus of the plasma display pane, the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

In the energy recovering apparatus of the plasma display panel, the second switching element includes third and fourth switches arranged in parallel with each other between the inductor and the panel, a first diode connected between the third switch and the panel capacitor to interrupt a reverse current from the panel capacitor, and a second diode connected between the fourth switch and the panel capacitor to interrupt a reverse current from the fourth switch.

In the energy recovering apparatus of the plasma display panel, the third switch forms a current path between the inductor and the panel via the first diode during a period while a voltage across the panel rises from the sustain voltage having the second polarity to the sustain voltage having the first polarity.

In the energy recovering apparatus of the plasma display panel, the fourth switch forms a current path between the inductor and the panel via the second diode during a period while a voltage across the

panel falls from the sustain voltage having the first polarity to the sustain voltage having the second polarity.

An energy recovering method of a plasma display panel according to an embodiment of the present invention includes a first step of charging a voltage from a power supply to the panel via one switching element; and a second step of recovering energy stored in the panel by a resonance with the panel to supply the recovered energy to the panel.

In the energy recovering method of the plasma display panel, the first step includes a step of charging a sustain voltage having a first polarity supplied from a first power source to the panel, and a step of charging a sustain voltage having a second polarity opposite to the first polarity supplied from a second power source to the panel.

In the energy recovering method of the plasma display panel, the first step further includes a step of forming a current path between the first power source and the panel using a first switch and a step of forming a current path between the second power source and the panel using a second switch.

In the energy recovering method of the plasma display panel, the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

In the energy recovering method of the plasma display panel, the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

In the energy recovering method of the plasma display panel, wherein the second step includes a step of forming a current path between the inductor and the panel using a third switch, a step of interrupting a reverse current from the panel using a first diode connected between the third switch and the panel, a step of forming a current path between the inductor and the panel using a fourth switch, and a step of interrupting a reverse current from the fourth switch using a first diode connected between the fourth switch and the panel.

In the energy recovering method of the plasma display panel, the third switch forms a current path between the inductor and the panel via the first diode during a period while a voltage across the panel rises from the sustain voltage having the second polarity to the sustain voltage having the first polarity.

In the energy recovering method of the plasma display panel, the fourth switch forms a current path between the inductor and the panel via the second diode during a period while a voltage across the panel falls from the sustain voltage having the first polarity to the sustain voltage having the second polarity.

Other objects than the above objects and features of the present invention will be apparent through descriptions on embodiments with reference to accompanying drawings.

Hereinafter, embodiments of the present invention will be described with reference to Figs. 7 to 12.

Referring to Fig. 7, an energy recovering apparatus of a plasma display panel (hereinafter, referred to as "PDP") according to an

embodiment of the present invention includes a panel capacitor Cp provided equivalently with first and second electrodes of the PDP, a first sustain voltage source +VS that generates a voltage +VS having a first polarity, a second sustain voltage source that generates a voltage -VS having a second polarity which is opposite to the first polarity, a first switch Q1 connected between the first sustain voltage source +VS and one end, i.e. a first electrode of the panel capacitor Cp, a second switch Q2 connected between the second sustain voltage source -VS and the first electrode, an inductor L connected between a first node point N1 between the first and second switches Q1 and Q2 and a second node point N2 between the first and second voltage sources +VS and -VS, and third and fourth switches Q3 and Q4 connected in parallel with each other between the inductor L and the first node point N1.

The first sustain voltage source +VS generates a positive sustain voltage +VS that is supplied to the panel capacitor Cp. The second sustain voltage source -VS generates a negative sustain voltage -VS that is supplied to the panel capacitor Cp.

Each of the first switch Q1 and the second switch Q2 is connected in parallel with one end of the panel capacitor Cp, that is, the first node point N1 (first electrode). The third switch Q3 and the fourth switch Q4 are connected in parallel with each other in the different direction from each other between the inductor L and the first node point N1. The inductor L is connected to the panel capacitor Cp through the third switch Q3 and the fourth switch Q4 to recover energy by an LC natural resonance with the panel capacitor Cp and then supplies the

recovered energy to the panel capacitor Cp.

The first switch Q1 to fourth switch Q4 are sequentially turned on to control the flow of currents. A diode is connected in parallel with each of the first switch Q1 to the fourth switch Q4. The diode may be used as an inner diode of each of the first switch Q1 to the fourth switch Q4. And, the diode may be used as an outer diode. In the meanwhile, each of the first switch Q1 to the fourth switch Q4 may use a semiconductor switching element, for example, any one of MOSFET, IGBT, SCR, and BJT.

In the meanwhile, a first diode D1 is connected between the third switch Q3 and the first node point N1 to interrupt a reverse current from the panel capacitor Cp, and a second diode D2 is connected between the fourth switch Q4 and the first node point N1 to interrupt a reverse current from the fourth switch Q4.

Fig. 8 is a timing diagram and a waveform diagram illustrating on/off timing of the switches shown in Fig. 7 and a voltage applied to the panel capacitor.

An energy recovering apparatus and method of a PDP according to an embodiment of the present invention will be described with reference to Fig. 8.

Among the first switch Q1 to the fourth switch Q4, only the first switch Q1 turns on during a period T0 to form a current path connecting from the first sustain voltage source +VS through the first switch Q1, the first node point N1, the panel capacitor Cp, and the second node point N2 back to the VS as shown in Fig. 9. Accordingly, the panel

capacitor Cp charges a sustain voltage +VS supplied from the first sustain voltage source +VS. This enables the panel capacitor Cp to maintain the positive sustain voltage +VS.

During a period T1, the first switch Q1 turns off and the fourth switch Q4 only turns on to form a current path connecting from the panel capacitor Cp through the first node point N1, the second diode D2, the fourth switch Q4, and the inductor L back to the panel capacitor Cp as shown in Fig. 10. Accordingly, the inductor L recovers the energy charged to the panel capacitor Cp by a LC-natural resonance with the panel capacitor Cp and supplies the recovered energy back to the panel capacitor Cp. This enables the voltage applied across the panel capacitor Cp to fall from the positive sustain voltage +VS to the negative sustain voltage -VS.

During a period T2, the fourth switch Q4 turns off and the second switch Q2 only turns on to form a current path connecting from the second sustain voltage source -VS through the second node point N2, the panel capacitor Cp, the first node point N1, and the second switch Q2 back to the second sustain voltage source -VS as shown in Fig. 11. This enables the panel capacitor Cp to receive the negative sustain voltage -VS from the second sustain voltage source -VS and maintain the negative sustain voltage -VS.

During a period T3, the second switch Q2 turns off and the third switch Q3 only turns off to form a current path connecting from the panel capacitor Cp through the second node point N2, the inductor L, the third switch Q3, the first diode D1, and the first node point N1

back to the panel capacitor Cp as shown in Fig. 12. Accordingly, the inductor L recovers the energy charged to the panel capacitor Cp by an LC-natural resonance with the panel capacitor Cp and supplies the recovered energy back to the panel capacitor Cp. This enables the voltage applied across the panel capacitor Cp to rise from the negative sustain voltage -VS to the positive sustain voltage +VS.

Periodic repetition of such periods T1 to T3 enables an AC sustain pulse VCP to be supplied to the panel capacitor Cp. In reality, an AC driving pulse (VCP) supplied to a first electrode Y and a second electrode Z of the plasma display panel is generated while the above-mentioned periods T1 to T3 are repeated periodically.

The energy recovering apparatus and method of the PDP according to the embodiment of the present invention recovers energy to the panel capacitor Cp using an LC-natural resonance between the inductor L and the panel capacitor Cp and supplies the recovered energy back to the panel capacitor Cp. Accordingly, the energy recovering apparatus and method of the PDP according to the embodiment of the present invention places only one inductor and only one switching element between the first electrode Y and the second electrode Z, that is, over an energy recovering current path of the panel capacitor and this may minimize the conductive losses and switching losses of semiconductor elements. Accordingly, the energy recovering apparatus and method of the PDP according to the embodiment of the present invention may minimize the losses of the energy recovering circuit.

[Effect of the Invention]

As described above, the energy recovering apparatus and method of the plasma display panel according to the embodiment of the present invention charges energy to the inductor while a sustain voltage is supplied to the panel capacitor, and recovers the energy charged to the panel capacitor using a reverse voltage upon energy recovery, with the recovered energy supplied back to the panel capacitor. This enables the rising and falling slope of the sustain waveform to be steep upon energy recovery.

Further, the present invention has an advantage of being capable of configuring an energy recovering apparatus at only one of the first and second electrodes of the plasma display panel. Since only one switching element exists over the sustain current path, the present invention may minimize the conductive losses by the switching element. In the meanwhile, the present invention may reduce consumption power because of four switching elements and two diodes.

The present invention, while described herein with reference to particular illustrative embodiments, need not be restricted by such embodiments but only by the appended claims. Those skilled in the art can change or modify the embodiments without departing from the scope of the present invention.

[CLAIMS]

[Claim 1]

An energy recovering apparatus of a plasma display panel comprising:

a plasma display panel;

a power supply supplying a sustain voltage to the panel via a first switching element;

an inductor recovering energy stored in the panel by a resonance with the panel and supplying the recovered energy to the panel; and

a second switching element forming a current path between the inductor and the panel.

[Claim 2]

The energy recovering apparatus of the plasma display panel of claim 1, wherein the power supply includes a first power source charging a sustain voltage having a first polarity to the panel and a second power source charging a sustain voltage having a second polarity opposite to the first polarity to the panel.

[Claim 3]

The energy recovering apparatus of the plasma display panel of claim 2, wherein the first switching element includes a first switch forming a current path between the first power source and the panel and a second switch forming a current path between the second power source and the panel.

[Claim 4]

The energy recovering apparatus of the plasma display panel of claim 3, wherein the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

[Claim 5]

The energy recovering apparatus of the plasma display panel of claim 3, wherein the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

[Claim 6]

The energy recovering apparatus of the plasma display panel of claim 1, wherein the second switching element includes third and fourth switches arranged in parallel with each other between the inductor and the panel, a first diode connected between the third switch and the panel capacitor to interrupt a reverse current from the panel capacitor, and a second diode connected between the fourth switch and the panel capacitor to interrupt a reverse current from the fourth switch.

[Claim 7]

The energy recovering apparatus of the plasma display panel of claim 6, wherein the third switch forms a current path between the inductor

and the panel via the first diode during a period while a voltage across the panel rises from the sustain voltage having the second polarity to the sustain voltage having the first polarity.

[Claim 8]

The energy recovering apparatus of the plasma display panel of claim 6, wherein the fourth switch forms a current path between the inductor and the panel via the second diode during a period while a voltage across the panel falls from the sustain voltage having the first polarity to the sustain voltage having the second polarity.

[Claim 9]

An energy recovering method of a plasma display panel comprising:

a first step of charging a voltage from a power supply to the panel via one switching element; and

a second step of recovering energy stored in the panel by a resonance with the panel to supply the recovered energy to the panel.

[Claim 10]

The energy recovering method of the plasma display panel of claim 9, wherein the first step includes a step of charging a sustain voltage having a first polarity supplied from a first power source to the panel, and a step of charging a sustain voltage having a second polarity opposite to the first polarity supplied from a second power source to the panel.

[Claim 11]

The energy recovering method of the plasma display panel of claim 10, wherein the first step further includes a step of forming a current path between the first power source and the panel using a first switch and a step of forming a current path between the second power source and the panel using a second switch.

[Claim 12]

The energy recovering method of the plasma display panel of claim 11, wherein the

the first switch forms a current path between the first power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the first polarity.

[Claim 13]

The energy recovering method of the plasma display panel of claim 11, wherein the second switch forms a current path between the second power source and the panel during a period while a voltage across the panel is maintained as a sustain voltage having the second polarity.

[Claim 14]

The energy recovering method of the plasma display panel of claim 9, wherein the second step includes a step of forming a current path between the inductor and the panel using a third switch, a step of interrupting a reverse current from the panel using a first diode

connected between the third switch and the panel, a step of forming a current path between the inductor and the panel using a fourth switch, and a step of interrupting a reverse current from the fourth switch using a first diode connected between the fourth switch and the panel.

[Claim 15]

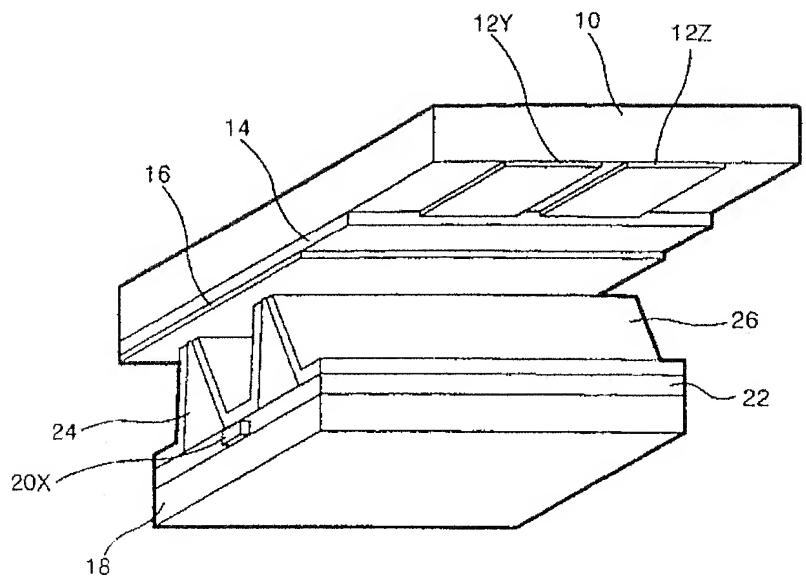
The energy recovering method of the plasma display panel of claim 14, wherein the third switch forms a current path between the inductor and the panel via the first diode during a period while a voltage across the panel rises from the sustain voltage having the second polarity to the sustain voltage having the first polarity.

[Claim 16]

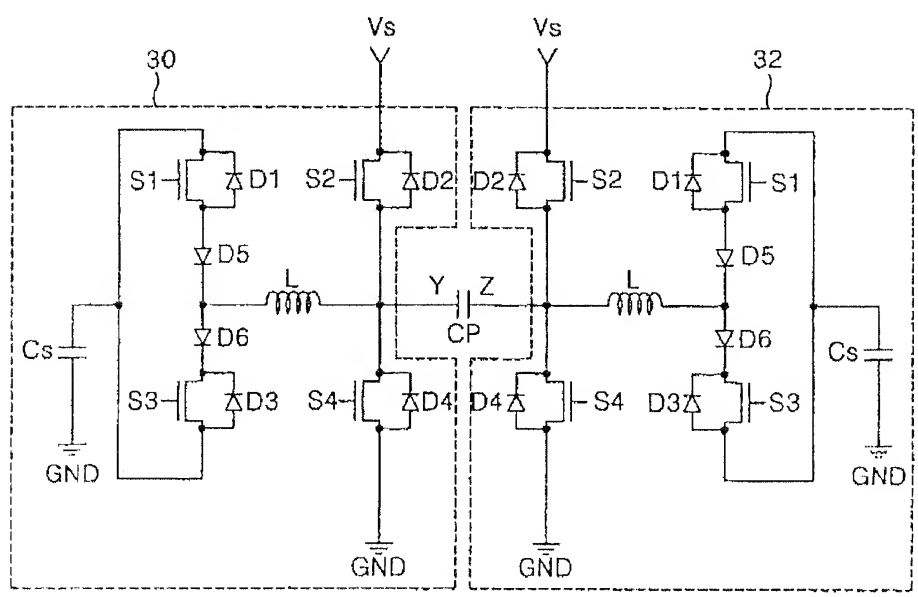
The energy recovering method of the plasma display panel of claim 14, wherein the fourth switch forms a current path between the inductor and the panel via the second diode during a period while a voltage across the panel falls from the sustain voltage having the first polarity to the sustain voltage having the second polarity.

[DRAWINGS]

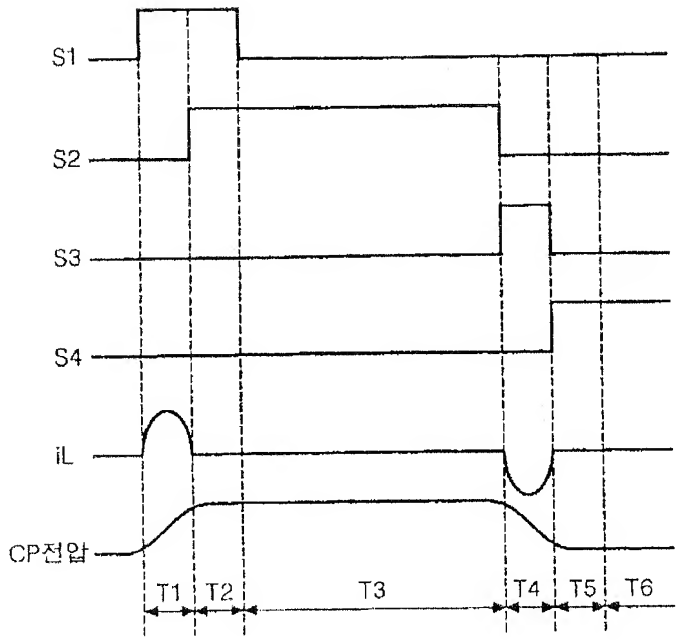
[FIG. 1]



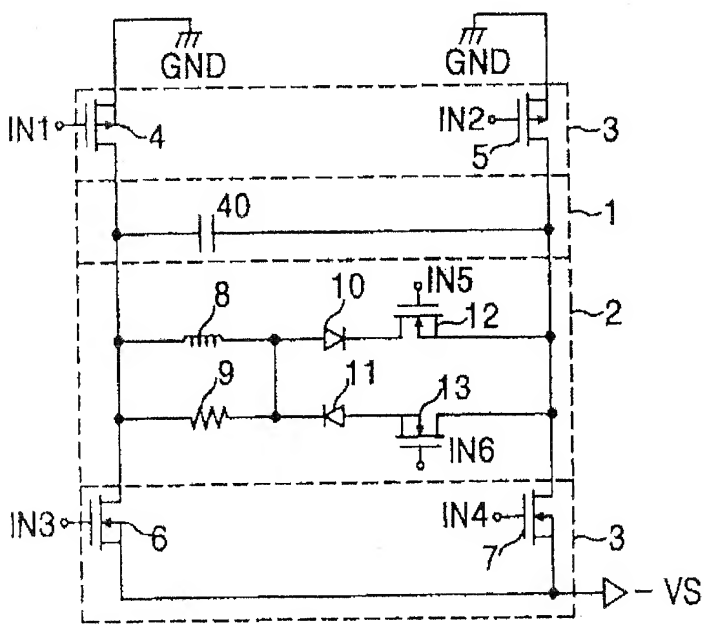
[FIG. 2]



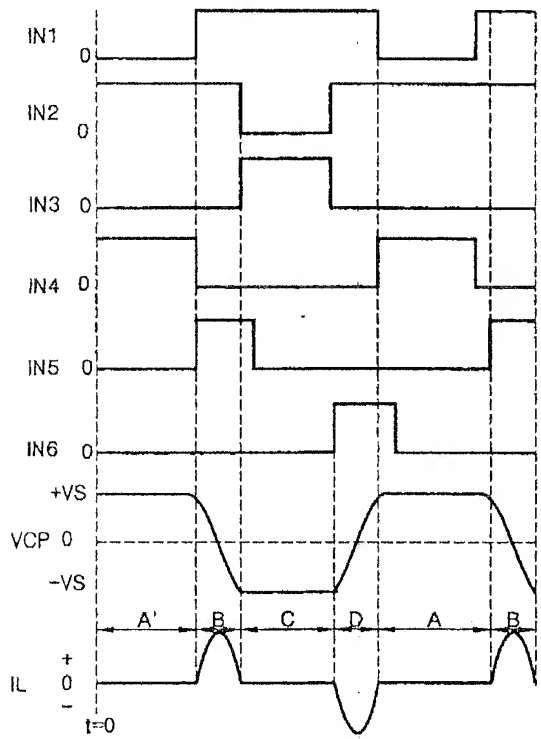
[FIG. 3]


S1
S2
S3
S4
iL
CP전압
T1
T2
T3
T4
T5
T6

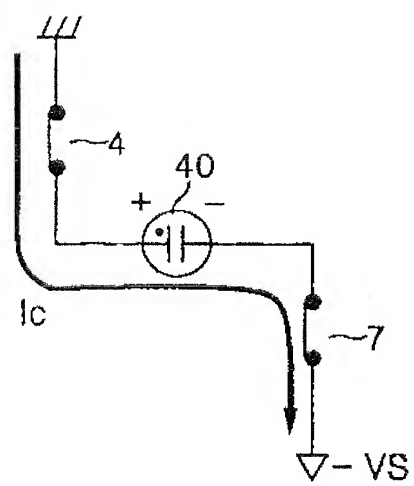
[FIG. 4]


GND
GND
IN1
4
IN2
5
3
40
1
8
10
IN5
12
2
9
11
13
IN6
IN3
6
IN4
7
3
VS

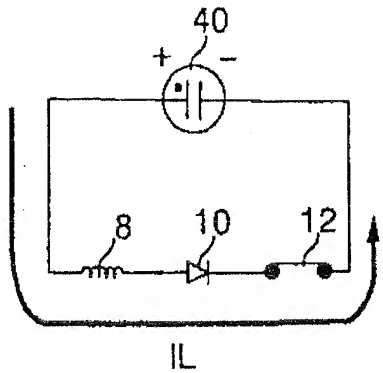
[FIG. 5]


IN1
0
IN2
0
IN3
0
IN4
0
IN5
0
IN6
0
+VS
VCP
0
-VS
A'
B
C
D
A
B
IL
+
0
-
t=0

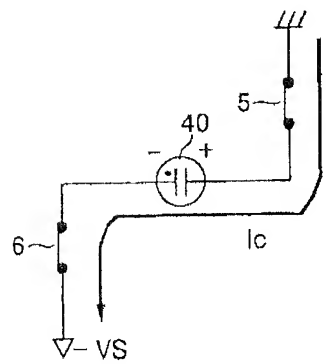
[FIG. 6a]


4
40
+
-
Ic
7
- VS

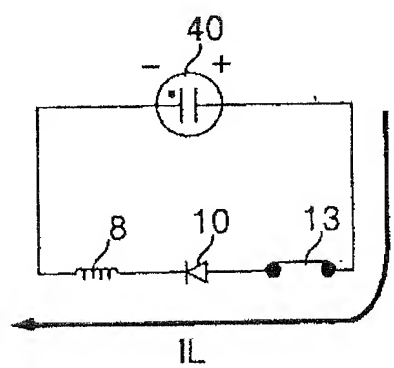
[FIG. 6b]



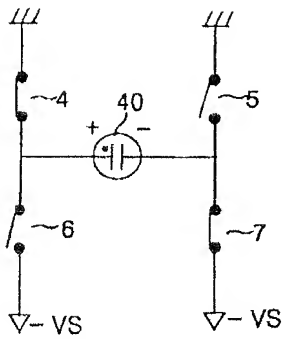
[FIG. 6c]



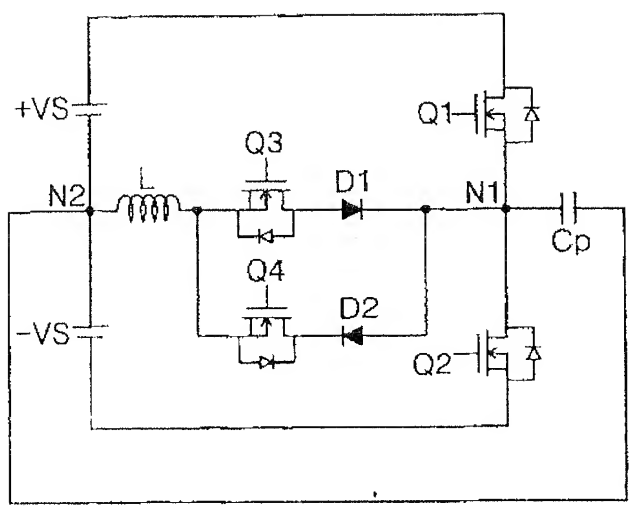
[FIG. 6d]



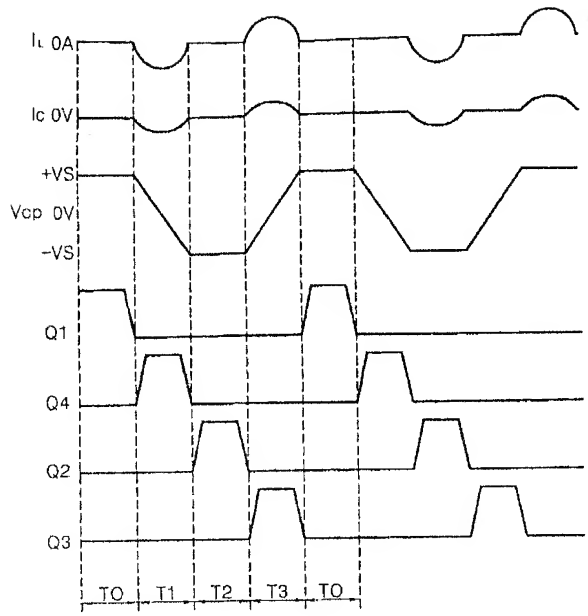
[FIG. 6e]



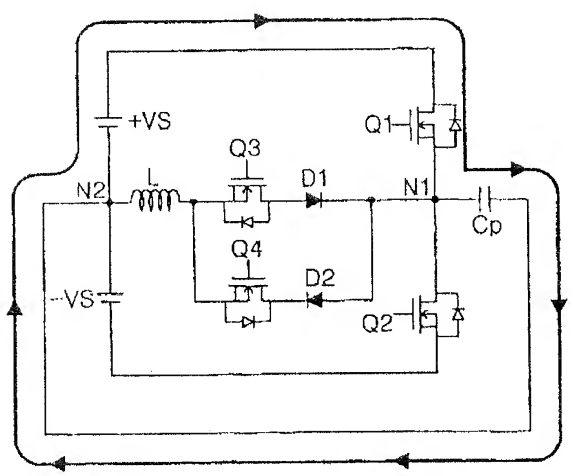
[FIG. 7]



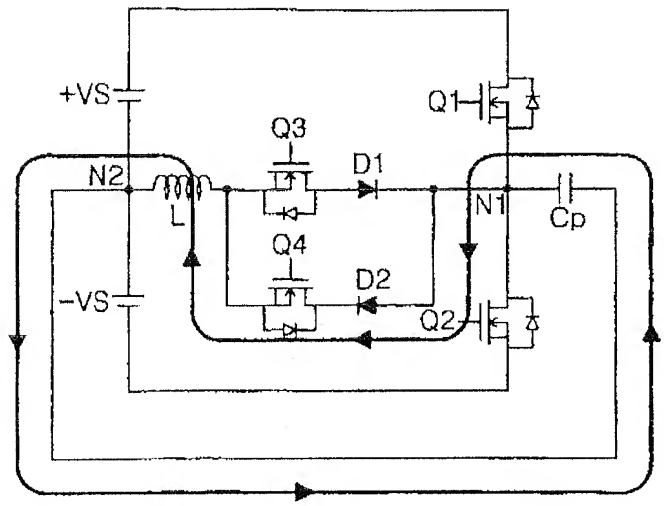
[FIG. 8]


IL 0A
Ic 0V
+VS
Vcp 0V
-VS
Q1
Q4
Q2
Q3
TO
T1
T2
T3
TO

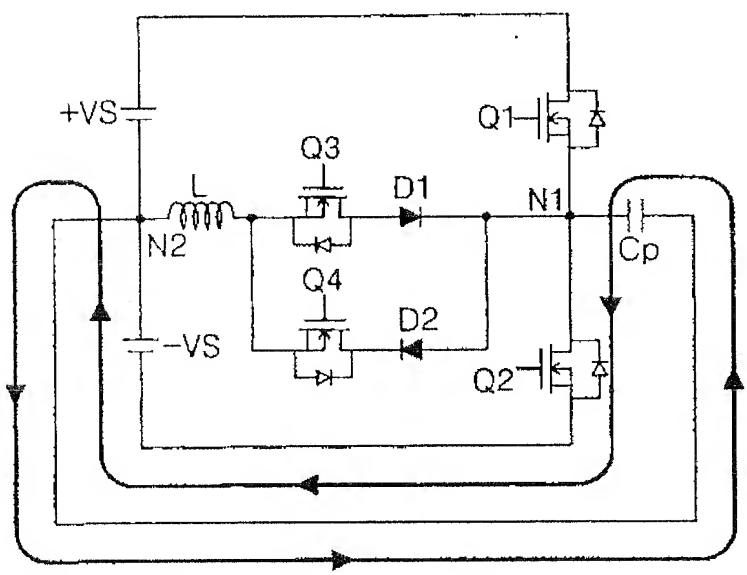
[FIG. 9]


+VS
Q1
Q3
N2
L
D1
N1
Cp
Q4
D2
-VS
Q2

[FIG. 10]



[FIG. 11]



[FIG. 12]